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AND INTERFERENCES

Paper No. 12

Application Number: 09/689,930
Filing Date: October 13, 2000
Appelant(s): LIU ET AL.

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George O. Saile
For Appellant

EXAMINER'S ANSWER

(1) Real Party in Interest

A statement identifying the real party in interest is contained in the Brief.

(2) Related Appeals and Interferences

A statement identifying the related appeals and interferences which will directly affect or be directly affected by or have a bearing on the decision in the pending appeal is contained in the Brief.

(3) Status of Claims

The statement of the status of the claims contained in the Brief is correct.

(4) Status of Amendments After Final

No amendment after final has been filed.

(5) Summary of Invention

The summary of invention contained in the brief is deficient because.

Appellants claim to have *developed* " the use of a 'high contrast' positive photoresist system" with *optimized* sensitivity to different radiations and different selectivity to etching (see Brief: p.3). The Appellants further claim to have "especially formulated" the two photoresists to exhibit different etch resistant properties (see Brief: p.18).

There is no evidence in the disclosure or in the claims for the "development" of such a unique resist system. The compositions and methods of use of the formulated resists are not detailed. The similarity of the claimed resist system with conventionally used and commercially available resists cited in prior art has not been refuted. Deep UV (DUV) and near UV resists are routinely used in the art as shown by the cited reference. The terms "high contrast", "etch selectivity", "thermal stability" and "good adhesion" used to characterize the resists are qualitative and apply to most commercially available resists.

The use of two resists with the listed properties is claimed as a key element of the invention.

The dual damascene process is a method of connecting two vertically separated layers of conductors. Using photoresists, a mold is formed in the intervening dielectric

layers and filled with metal to connect the layers. The dual damascene process differs from conventional interconnect techniques in that the upper section of the mold is in the shape of a line ("Trench") while the lower section is shaped as a pillar (Via). In conventional interconnects, a single vertical pillar of metal is formed (Via).

(6) Issues

The appellants' statement of the issues in the brief is correct.

(7) Grouping of Claims

The rejection of claims 1-30 stand or fall together because Appellant's brief does not include a statement that this grouping of claims does not stand or fall together and reasons in support thereof. See 37 CFR 1.192(c)(7).

(8) Claims Appealed

The copy of the appealed claims contained in the Appendix to the brief is correct.

(9) Prior Art of Record

6110648	***Jang***	***08-2000***
4770739	***Orvek***	***09-1988***
6103456	***Tobben***	***08-2000***
5843847	***Pu***	***12-1998***

(10) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claims 1-7,9-17,19-27,29,30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jang in view of Tobben and further in view of Orvek . The numbers in parentheses refer to the column;line numbers of the reference under discussion.

The listed claims recite a dual damascene process using two photoresists with different spectral sensitivities, to form a trench and an aligned via in a multilayered substrate.

Jang teaches the dual damascene method for enclosing a copper conductor in a multilayered substrate. The three layered stack consists of (a) lower layer dielectric (LLD) (b) an intermediate etch stop layer and (c) an upper dielectric layer (ULD) over other layers on a substrate (5;27-29). The low permittivity dielectrics are formed of silicon oxide materials known in the art (5;40-47). The etch stop layer consists of silicon-nitrides and -oxynitrides (5;53-57)

The processing steps include: forming a first photoresist layer and patterning it for a via (5;64-65); forming a second photoresist layer and patterning it for a conductive line (6;12-14); etching the diverse layers to form a via and a trench (5;64-6;26); removing the resist layers and forming a barrier layer (6;26-42); filling the trench and via with metal; and planarizing with a chemical mechanical polish (CMP)—(6;43-47).

Jang's invention is related to the manufacture of IC chips and to forming interconnects between layers on semiconductor substrates (1;7-12). Multilevel structures can be formed by repeating the process (2;3-6).

Jang does not teach the use of a top insulating dielectric layer over the three-layer stack recited in claims 1,5,11,15,21,25. It does not teach the use of a near-UV (365nm) and a deep UV (268nm) photoresist recited in claims 1,6,7,11,16,17,21,26,27.

Tobben teaches the prior-art of dual damascene process with the use of a silicon oxynitride (SiON) layer as an anti-reflective coating (ARC) – (5;13-25). It teaches the benefits of using SiON (4;19-28). These include the anti-reflection function under the photoresist, controlled deposition as well as suitability for hard masks.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to use SiON as a top dielectric layer over Jang's stack because Tobben teaches that it functions as an ARC as well as a hard mask for etching , leading to improved feature definition in the resist and etching of holes in the dielectrics (Tobben: 6;1-10)

Orvek teaches the use of two resists with different spectral sensitivities. It teaches a bilayer method where the lower layer (planarization layer) is a near-UV resist while the upper layer (resolution layer) is a deep UV resist (4;10-13). The near-UV resist is sensitive to radiation in the 310-395nm range while the deep-UV resist is sensitive in the 185-310nm range (5;17-19,22-24). In one embodiment the upper layer is imaged with a 248nm radiation (8;Ex.1) and developed. The lower layer is blanket exposed to transfer the image in the areas of the developed upper layer and developed. Orvek teaches that this scheme increases resolution of images in the deep-UV resist; because the lower layer absorbs the deep-UV radiation and minimizes aberrations from reflections (6;25-38). Additionally the lower layer performs as a superior dry etch mask

compared with deep UV resists (9;33-37). Orvek teaches its application in a metallization process (9;66-67).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to use a deep-UV resist over a near-UV resist in Jang and Tobben's damascene process because Orvek teaches that it increases image resolution in the resist (5;61;-65) and feature resolution during dry etching of stepped features (6;39-48).

Claims 8,18,28 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jang in view of Tobben and further in view of Orvek and further in view of Pu.

The current claims relate to etchant chemistries and process parameters for reactive ion etching of dielectric layers in a dual damascene process.

The teachings of Jang have been discussed above. Jang teaches the two-step etching of dielectric layers using fluorocarbons and Ar, ashing of resist (6;3-11,20-24). Jang's chemistries do not include oxygen-bearing gases.

Pu teaches the etching of dielectric layers and resists (2;35-38). The components of the process gas comprise a fluorocarbon, carbon-oxygen and nitrogen-bearing gases (2;40-46). In a preferred embodiment the listed components include CHF3,CH3F, C2F6, C4F8, CF4 , N2O, N2 and Ar. It teaches prior-art compositions that include CO (1;65). The compositions and parameters are adjustable to the materials being etched (7;42-48).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to use Pu's process to etch the layers on Jang and Tobben's stack with Orvek's resists, because PU teaches that this leads to better etch-selectivity, high etch-rates and low organic contamination (8;34-38) while providing vertical wall profiles (Tables I,III)

(11) Response to Argument

As stated by the Appellants , the heart of the invention is in the limitations of independent claim 1. Examiner has discussed the elements of the instant claim 1 that are taught by Jang, the primary reference, in the prior office action, Paper No. 4. and reproduced above. These are listed again for clarity.

Claim 1 recites:

"Providing a substrate over which is formed a composite layers of insulation comprising a first layer of dielectric separated form a second layer of dielectric by an intermediate etch stop layer of dielectric". Jang (5;27-29) teaches in Fig. 3A two layers of dielectric, a lower layer dielectric (LLD) and an upper layer dielectric (ULD) separated by an intervening etch stop layer.

The claim next recites: "forming a top dielectric layer over said composite layers of dielectric;". Jang does not teach a top dielectric layer.

The claim then states: "Forming a first photoresist layer over said composite layers of insulation and top insulating layer;". Jang (5;64) teaches forming a first photoresist layer over the three-stack composite layer of insulation.

The claim further recites: "Patterning a via hole pattern in said first photoresist layer by exposing to I-line 365nm radiation and developing;". Jang (5;66) teaches patterning a via pattern in the first photoresist; it does not teach using I-line 365nm radiation. It does not explicitly teach developing but is inherent to the patterning process.

The claim further recites: "Forming a second photoresist layer over via patterned said first photoresist layer;". Jang (6;12) teaches forming a second photoresist layer over the via; however it does not form the second resist layer over the first photoresist layer.

The claim further recites: "Patterning a trench line pattern in the second photoresist layer by exposing to deep-UV 248 nm radiation and developing;". Jang (6;13) teaches forming a trench pattern with the second photoresist. It does not teach using deep-UV 248 nm radiation. It does not explicitly teach developing – but is inherent to the process and also in view of the next step.

The subsequent steps of the claim are: " Etching the top and second layer of dielectric underlying the first layer of photoresist using the via hole pattern layer; Etching said intermediate layer of dielectric under second layer of dielectric using the first layer of photoresist as a mask;". Jang (6;1-3) teaches etching the ULD and etch stop layers forming the hole in the respective layers.

The claim next states: "Etching said composite layers of insulation transferring said trench line pattern into said first layer of photoresist and into said second layer of dielectric and transferring said via hole pattern into said intermediate layer of dielectric and into said first layer of dielectric;". Jang (6;15-20) teaches etching the conductive

line pattern into the ULD and simultaneously extending the hole pattern into the LLD layer. Jang does not teach transferring the trench pattern into the first photoresist layer.

The claim further recites: "Removing said layers of photoresists and filling the trench line and via hole openings with metal." Jang (6;26-7;8) teaches removing the second photoresist and filling the patterns with metal.

Jang's teachings differ from the instant claim in the following respects:

(a) Jang does not teach " forming a top dielectric layer over said composite layers of dielectric;"

(b) Jang uses two resists which may not be sensitive to different radiations.

(c) The processing sequences of the layers in the two instances are different. In Jang's invention, the two resist layers are formed and processed in sequence; i.e. the first resist layer is used to form the vias and *is removed* prior to the application of the second resist layer. In the instant claim the two resist layers are <u>*patterned*</u> *in sequence.* These have been addressed in the earlier office action as follows:

Tobben teaches the use of a top dielectric in a dual damascene process, which also serves as an antireflection coating (ARC). Tobben teaches that the ARC also functions as a hard mask for etching. Thus one of ordinary skill in the art would include a top dielectric layer before applying the first photoresist layer, in a dual damascene process, because it not only improves the image formation but also serves as a hard mask while transferring the image by subsequent etching. The structure of the instant claimed stack would result directly from the combination of Tobben and Jang.

Appellants even recognize the resultant structure when they state in their Brief at page 15 line 1 "that the top dielectric is common to many processes" .

Orvek teaches the use of two resists with different spectral sensitivities (UV and DUV) in an interconnect metallization process similar to the dual damascene process. A bi-layered photoresist system is used to form a single interconnect with two exposure steps (i.e. the two images are identical in shape whereas in the dual damascene process the via and trench have different shapes). Orvek lists the criteria for selecting the two resists (Orvek: 7;1-27); the reference provides an example wherein one photoresist additionally functions as a hard mask providing high etch resistance (Orvek: 9;33-37). Thus Orvek teaches the use of a two-layered resist system wherein the two layers have different spectral sensitivities and etch-selectivity in a metallization operation. Improved image resolution during exposure of photoresists and increased feature definition due to etch selectivity are claimed for this scheme. Orvek recommends the process to all metallization processes (Orvek: 3;32-36).

Appellants have argued that Jang's invention is directed to a "method of enclosing copper conductor in a dual damascene process" (p.12) and uses "multiple etching steps" (p.13). Further, Appellants argue that Jang does not teach "the formation of self-aligned dual damascene interconnects and vias" (p.14).

Examiner would like to point out that Jang's invention is directed to a method of forming interconnects and vias by a dual damascene process. Jang's innovation lies in a method of filling the metal in the trenches and vias formed by the dual damascene

process (Jang; abstract). . The later-occurring steps of Jang's process are not an issue in the instant claims; Jang's intended use of the self-aligned trenches and vias do not detract from the method of forming them. Jang teaches most of the materials and process steps of the instant processes and is directed to the same art – namely a dual damascene process. The reference teaches only two etching steps. The via is first etched during the first etch step (Jang: 6;1-8); subsequently the trench is etched and the via is extended into the sub-layer at the same time using a second etch step (Jang: 6;11-20).

Appellants argue in page 14 of the Brief "Tobben's invention is focused on the prevention of photoresist poisoning".

Tobben discloses forming self-aligned trenches and vias for interconnects using a dual damascene process. The novelty in Tobben's invention lies in forming a top-dielectric layer over a three-layered composite structure similar to Jang's. The intended function of Tobben's dielectric layer does not detract from the structure. Appellants also recognize that this element (i.e. the top dielectric layer) is common to many processes in use including the instant claimed invention (see Brief: p.15).

Appellants argue against the Orvek reference by indicating that Orvek uses one mask with two resists to form the same pattern whereas the instant claim recites two patterns formed on two resists (see Brief: p.14). Appellants then assert that Orvek's disclosure is concerned with planarizing an irregular surface (see Brief: p.15). They also state that Orvek's scheme adds costly processing steps (see Brief: p.15). They then

conclude that there is no motivation to combine Orvek with Jang and Tobben (see Brief: p.16).

Examiner has noted above that Orvek teaches the materials and processes of the instant invention. In particular, the Appellant-"developed two resist system", with "optimized sensitivity to different radiations" (see Brief: p.3) and "especially formulated to exhibit different etch resistant properties" (see Brief: p.18), is identical to Orvek's resists. It may be noted that Orvek's resists are commercially available and the reference even teaches a method for selecting the two resists (Orvek: 7;1-27). Orvek applies the two-resist system to a process very similar to the dual damascene process – interconnect metallization. The concept of an interconnect is simple and same as the instant invention. The difference merely lies in the shape of the images formed on the two resists. The dual damascene process is a method of connecting two vertically separated layers of conductors. A mold is lithographically formed (using photoresists) in the intervening dielectric layers and filled with metal to connect the layers. It differs from conventional interconnect techniques in that the upper section of the mold is in the shape of a line ("trench") while the lower section is shaped as a pillar (Via). In conventional interconnects, a single vertical pillar of metal is formed (via).A skilled artisan would know to form two differently shaped images for a dual damascene step using Orvek's resists. This would also eliminate the additional steps and costs that are of concern to the Appellants. Orvek's resists possess the two main characteristics that are claimed by the Appellants for the instant resists – sensitivity to different wavelengths of radiation and selectivity in etch rates. It would be within the level of ordinary skill for

an artisan to use the two resists for patterning and to modify Jang's process comprising Tobben's dielectric layer.

Appellants argue that Pu's invention is concerned with selective etching and does not address the claimed invention. Pu etches only one resist layer. (see Brief: p.17).

However Pu teaches reactive ion etching of a resist using the same chemistry as the instant invention. The chemistry would be valid for the dielectric layer used and its interaction with the photoresist mask would be the same. Examiner especially notes that the Appellants seem to agree that these are widely used etch chemistries for the dielectrics under consideration (see Brief: p.18).

In summary:

In response to Appellants' argument that it would not be obvious to combine the cited references (see Brief: p.19), the test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference; nor is it that the claimed invention must be expressly suggested in any one or all of the references. Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981). Appellants have emphasized the two-resist system with different spectral sensitivity and etch selectivity. The disclosure does not define these resists; Appellants do not distinguish it from the commercially available resists

taught by Orvek. The damascene process wherein the first resist layer is not removed, is a variant of Orvek's and Jang's process; this too appears to have been recognized by the Appellants (specification; p.4,lines 15-22). The etch chemistries are widely used as recognized by the Appellants. One of ordinary skill in the art would know to incorporate the <u>known</u> prior-art materials in a <u>known</u> process to derive the <u>known</u> synergistic benefits of materials and process. These benefits include better feature definition due to Tobben's top dielectric as well as etch control (Tobben: 4;19-28); and better image resolution from Orvek's two-resist system. The different etch sensitivities of the resists further enhance the feature definition (mold accuracy) formed in the dielectrics (Orvek: 3;32-36) using Pu's etch chemistries. Appellants have not shown any *unexpected* results or benefits from the use of the resist system or the instant process.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

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May 20, 2003

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This is in response to the appeal Brief filed 3/11/03.